

Overview of ATLAS Pixel Tracker

Issues to address:

- The role of pixels in the ATLAS Inner Detector: LHC tracking goals
- Overview of the ATLAS pixel tracker
- The US roles in the ATLAS pixel tracker

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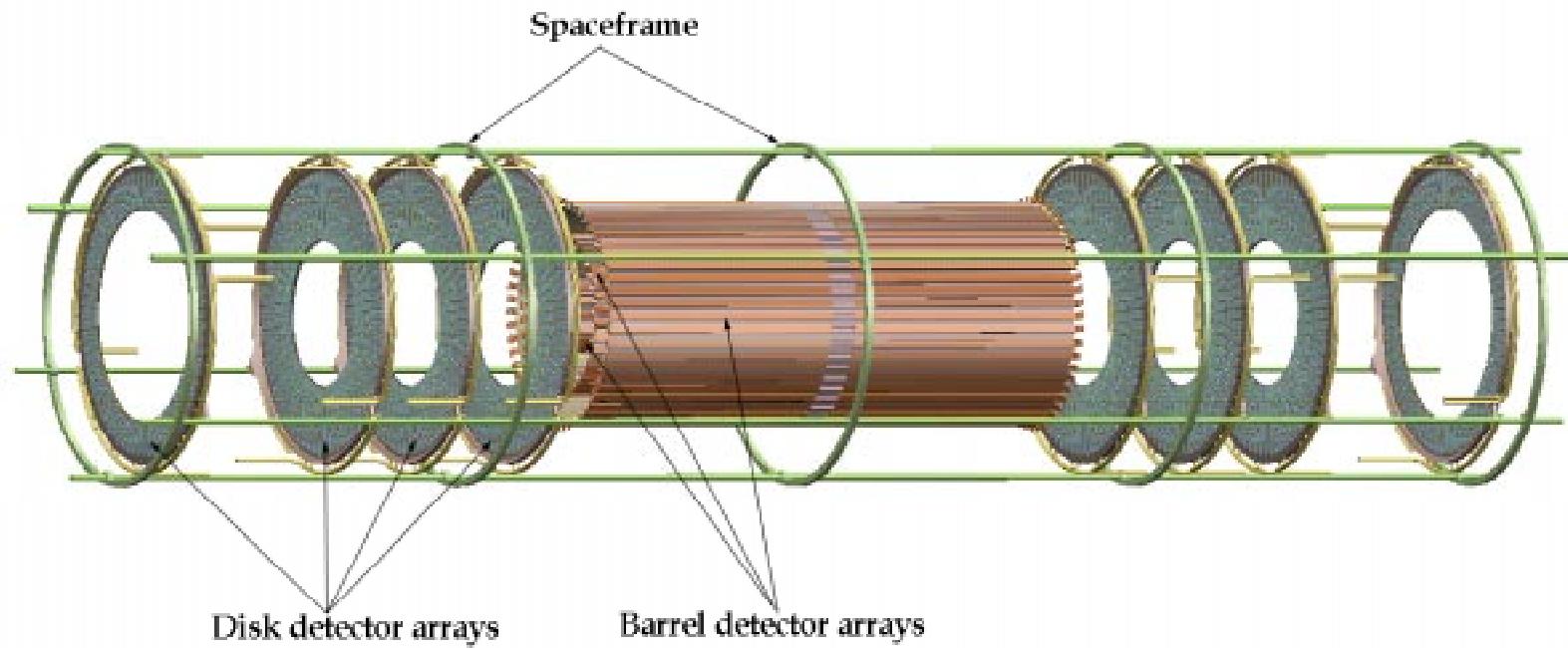
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Pixel Tracking in ATLAS

Pixel concept uniquely addresses many vital tracking issues at the LHC:

- Layout: consists of 2 barrels, 2 x 4 disks, and small radius barrel to optimize impact parameter resolution, providing $\approx 2.3 \text{ m}^2$ active area with $\approx 1.4 \times 10^8$ pixels



- **Radiation Hardness:** Principle issues are reduced signal size (low pixel capacitance reduces noise) and large leakage current (fine segmentation helps keep leakage below signal current). Signal size (\propto depletion depth) limited by bias breakdown voltage, implying ≈ 10 cm is smallest radius for full-lifetime operation in ATLAS:

- For a fluence of 10^{15} , expect $\approx 100\mu$ depletion at 200V bias, and loss of ≈ 4 in signal for 300μ silicon detectors. Ability to operate with only about 6Ke signals gains a factor ≈ 10 in lifetime.
- For this fluence, expect a leakage current of ≈ 30 nA for $50\mu \times 300\mu$ pixels at $0^\circ C$

- **Pattern Recognition:** Cope with ≈ 25 interactions/crossing at design luminosity

- At design luminosity and 10 cm, the pixel occupancy is $\approx 10^{-4}$. It is 4-5 times worse at 4-5 cm

- **Parametric Performance:** Provide optimal impact parameter and z measurement with very low ambiguity

- Binary readout should provide a point resolution of $\approx 14\mu$ in $r\phi$ and $\approx 60\mu$ in z. Modest charge measurement could improve this by perhaps a factor of 2.

- **Material:** Provide space points with a material budget per layer of $< 2\% X_0$

- Support structure must provide significant cooling, and accurate positioning from $20^\circ C$ to $-15^\circ C$

- **Coverage:** Need coverage over complete $|\eta| < 2.5$ tracking region

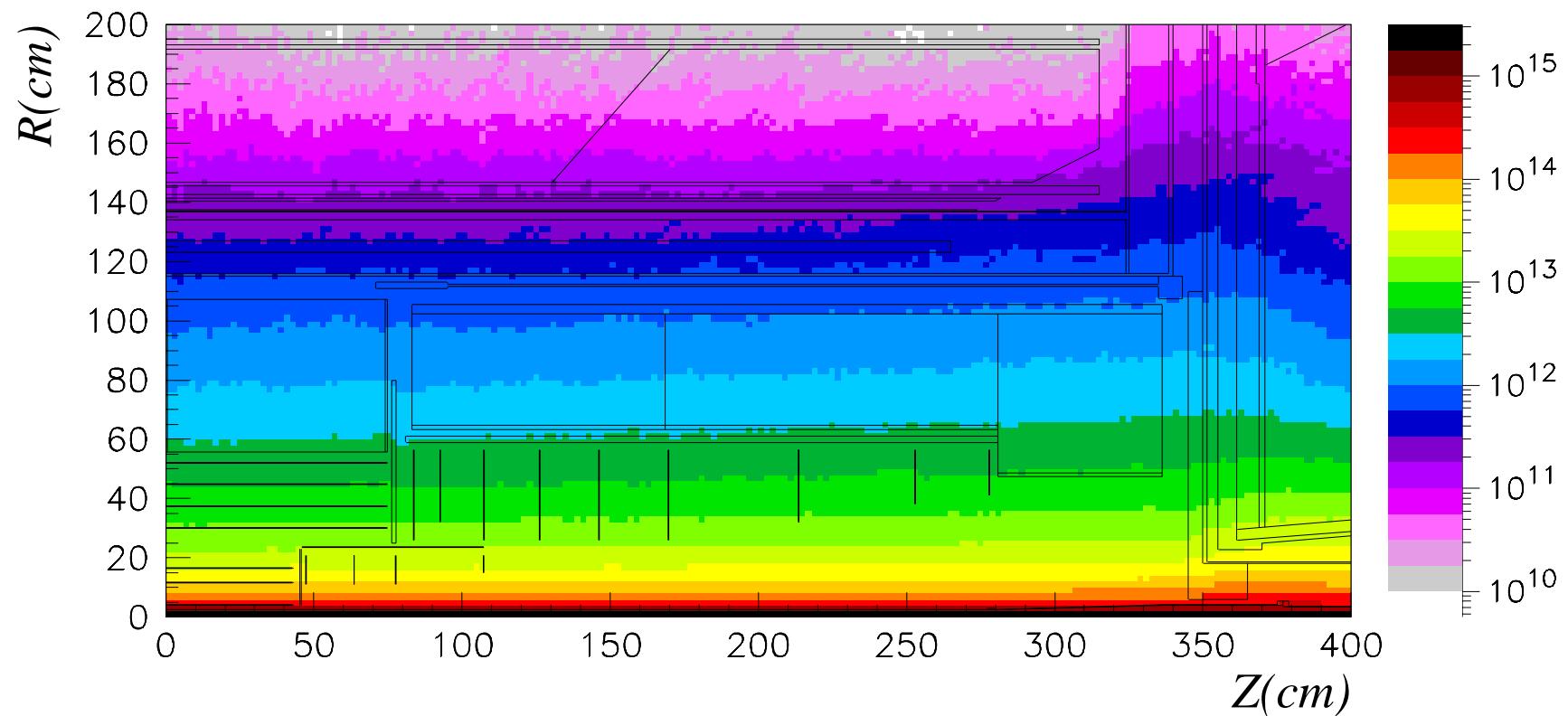
- Combination of barrel and disk layers provide good uniformity for $\pm 2\sigma$ in z

- **Trigger:** Space points and excellent resolution for $r\phi$ and $\tan\lambda$ make these layers vital for the L2 tracking trigger

Radiation in ATLAS Inner Detector

At small radii, where the pixel tracker lives, the total radiation dose is dominated by charged hadrons from the underlying events (true for all silicon layers in ATLAS)

- Fluence of charged hadrons through the ATLAS Inner Detector per cm^2 per year at design luminosity:



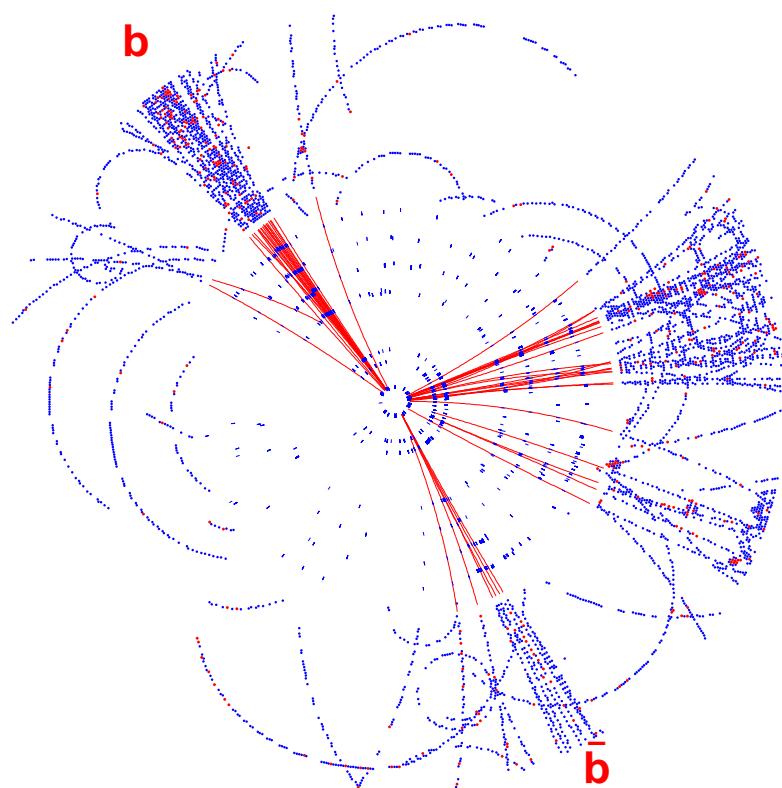
Pattern Recognition in ATLAS Inner Detector

H → bb event at zero luminosity and at design luminosity:

- Vertexing and b-tagging will be challenging, and need pixel detectors !
(Precision hits shown for $0 < \eta < 0.7$ only, TRT hits for $z > 0$ barrel only)

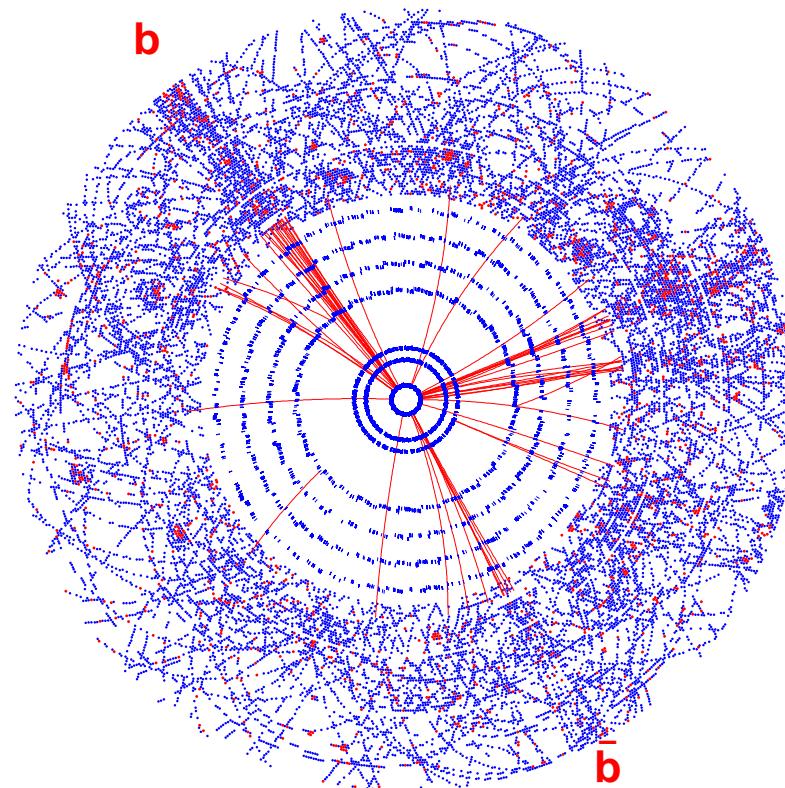
ATLAS Barrel Inner Detector

H → bb̄



ATLAS Barrel Inner Detector

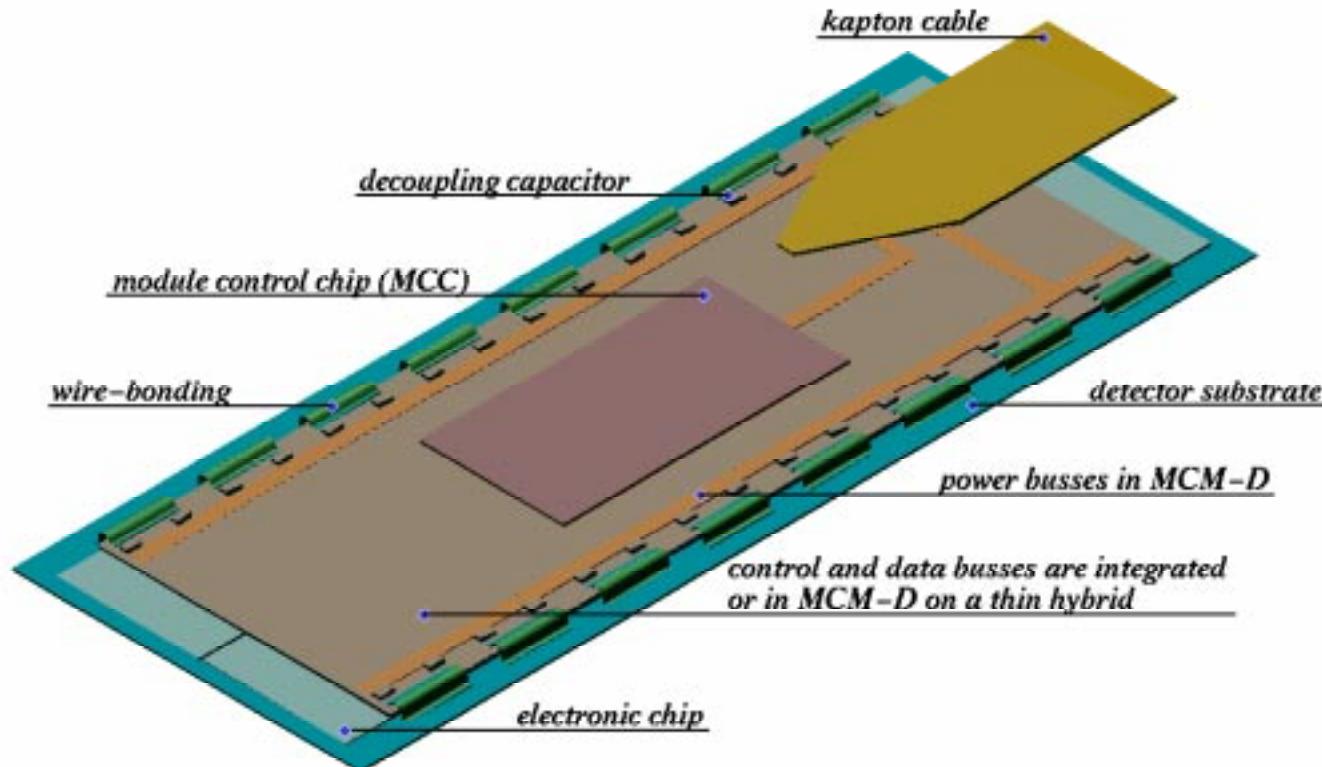
H → bb̄



Overview of ATLAS Pixel Tracker

Basic Components:

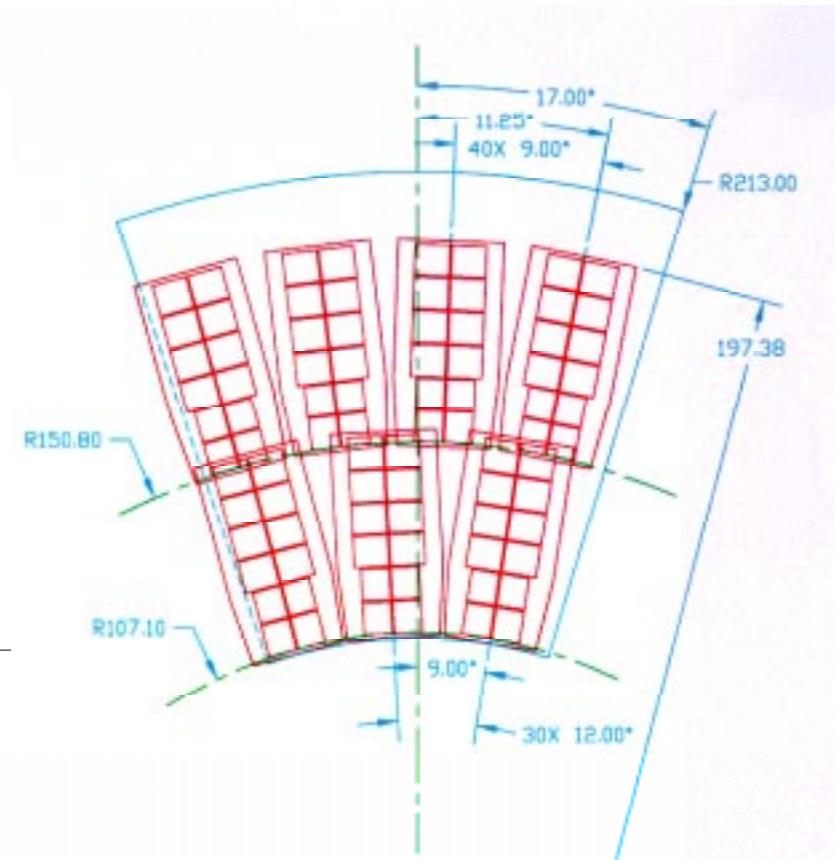
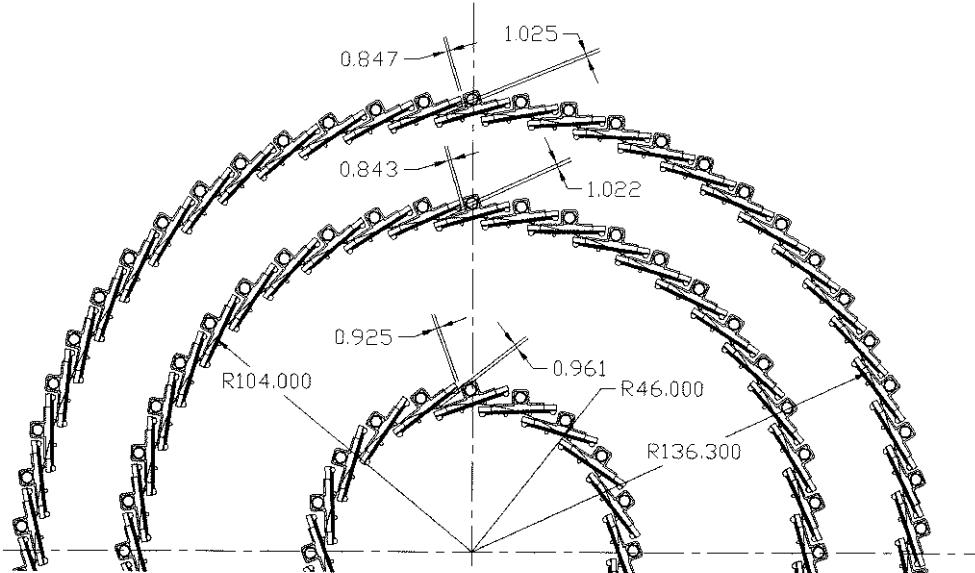
- Modules which are placed on a mechanical support and cooling structure:
 - Silicon detectors (one per module)
 - Electronics chips bump-bonded to detectors (12-16 FE chips and 1 Controller chip per module)
 - Hybrid interconnect that connects front-end chips to controller chip and services



- Mechanical support structure which also provides required ≈ 14 kW of cooling

→ A total of 1586 barrel modules are mounted on cooled staves, arranged in a pin-wheel geometry for overlap coverage, which are in turn supported by rings in a space frame

→ A total of 1000 disk modules are mounted on both sides of cooled plates which are supported by a space frame



US Roles in the ATLAS Pixel Tracker

Electronics (WBS 1.1.1.3):

- Significant design role in front-end chip ($\approx 50\%$) and overall system design, then procure/test wafers of front-end chips for disk system ($\approx 25\%$).

Detectors (WBS 1.1.1.2):

- Significant design role in detectors, then procure/test wafers for disk system ($\approx 20\%$)

Module Hybrids and Cables (WBS 1.1.1.4):

- Design and fabricate all hybrids and cables for disk system.

Module Assembly and Test (WBS 1.1.1.5):

- Assemble and test all modules for disk system.

Mechanics (WBS 1.1.1.1):

- Design, assemble and install complete mechanics for disk system.

Note: Disk system is $\approx 30\%$ of total area of the ATLAS pixel system, so US *does not supply all required components...*

European roles in ATLAS Pixel Tracker

Major groups, all focussing on barrel construction:

- France: CPPM/Marseille

Contributing to Front-end electronics, Detectors, Modules, and Mechanics

- Germany: Bonn/Dortmund/MPI-Munich/Siegen/Wuppertal

Contributing to Front-end electronics (Bonn/Siegen), Detectors (Dortmund/MPI), Modules (Wuppertal), Mechanics (Bonn)

- Italy: Genova/Milano/Udine

Contributing to Readout electronics (Genova), Detectors (Udine), Modules (Genova), and Mechanics (Genova)

- Others: NIKHEF (Readout electronics), Prague (Detectors)

Many major items will be purchased by common procurement

- Examples include detectors and electronics, to lower costs and enforce uniformity

In general, integration of US and European efforts is good:

- Several challenging areas have parallel efforts (front-end electronics, detector design, module design, cooling method) seeking the best solutions.

Project Organization

Project Manager: L. Rossi (Genova)

Steering Group consisting of coordinators:

Electronics:

- Front-end: P. Fischer (Bonn), K. Einsweiler (LBL)
- Readout: G. Darbo (Genova)

Detectors:

- S. Seidel (UNM), R. Wunstorf (Dortmund)

Modules:

- K-H. Becks (Wuppertal), P. DelPierre (CPPM)

Mechanics:

- D. Bintinger (LBL), G. Hallewell (CPPM)

Layout:

- G. Gilchriese (LBL)

Simulation:

- A. Rozanov (CPPM)